SKY Laboratories

CORNELL RURAL SCHOOL LEAFLET

VOLUME 46
NUMBER 3
WINTER 1952-53

CORNELL RURAL SCHOOL LEAFLET

PUBLISHED BY
THE NEW YORK STATE COLLEGE OF AGRICULTURE AT
CORNELL UNIVERSITY, ITHACA, NEW YORK
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A publication of the
New York State College of Agriculture,
a unit of the State University of New York,
at Cornell University

Acknowledgments: The help of Professor R. W. Shaw of the Department of Astronomy in planning this Leaflet and reviewing the manuscript is gratefully acknowledged. Thanks go, too, to the staff of the Trumansburg Central School, and to the children of grades 4, 5, and 6, whose questions and comments guided the choice of content.

Sky Laboratories

By Eva L. Gordon

My dictionary says that a laboratory is a place where scientific work is done. The sky then has been a laboratory for the peoples of the earth for many centuries. Shepherds, farmers, sailors, scholars, scientists, and many other persons have watched sky objects and sky happenings and have tried to understand what they saw. Many of the ancient sky watchers had no tools except their eyes and their brains. Some had the help of mathematics and other sciences. Among these sky watchers were many good observers and thinkers. Sometimes they were wrong or inaccurate, yet they discovered much that we still believe to be true. Their careful study was the beginning of the science of *astronomy*.

Astronomers now have telescopes, cameras, and many other instruments to help them see. They make use of other sciences, too, such as physics and mathematics. Do you wonder that they are able to add new and more nearly accurate knowledge year by year? Are you surprised that some old ideas have been proved wrong? Or that we expect, each year, to be better able to understand what the heavenly bodies are like, how they behave, and even why they behave as they do?

Long ago people found uses for what they saw in the sky. Men learned to tell time from the position of the sun by day and the stars by night. Sailors and other travelers used the sun and stars as guides for their journeys. Knowledge of the sky was used in other ways, too.

Today, we say we tell time by watches and clocks; but watches and clocks depend on sun time and star time. We still use the sun and the stars in navigation, whether we travel by land, by sea, or in the air. Astronomy has played a part in locating state and national boundaries, especially those that follow parallels and meridians. Even radios and television are partly the result of discoveries made by astronomers. Perhaps you can find other ways in which knowledge gained from sky laboratories is important to us today.

You who read this Leaflet have the same tools that all astronomers use – your eyes and your brains. In school, from books, and with other helps, probably you have already learned much about sky objects

and events. Perhaps as you begin each section of this Leaflet you should list what you know about its subject. At school, your class might make a list on the blackboard. You might add things you wish you knew. Then you will be ready to use the sky laboratories just outside your door – and sometimes inside, too – to help you learn more and to appreciate better the splendor and mystery of the sky.

Use your science textbooks as you work in your sky laboratories. Dictionaries and encyclopedias will help, too. Go to your library for books that deal with astronomy. Some are listed on pages 31 and 32.

As you observe and study and read you will discover much to do and learn about astronomy. Only a small part of a big story is here. Weather and climate are in part sky-laboratory studies, too, but they and other subjects must be left for later Leaflets.

The Earth

PERHAPS because we live on the earth, it is difficult for us to think of our earth as a part of the sky laboratory. But stop and think. All we know about the universe has been discovered by men *on* the earth. These men studied the earth and the things that happened on it as well as the sky and the objects and happenings there. Sometimes what they learned by earth studies helped them to learn about the sky.

Here are some earth studies you can make:

Shadows through the day

On the first sunny day after you receive this Leaflet, watch how shadows show that the sun seems to cross the sky. Find a stake, a post, a flagpole, or some similar object that is in sunlight all day. At nine

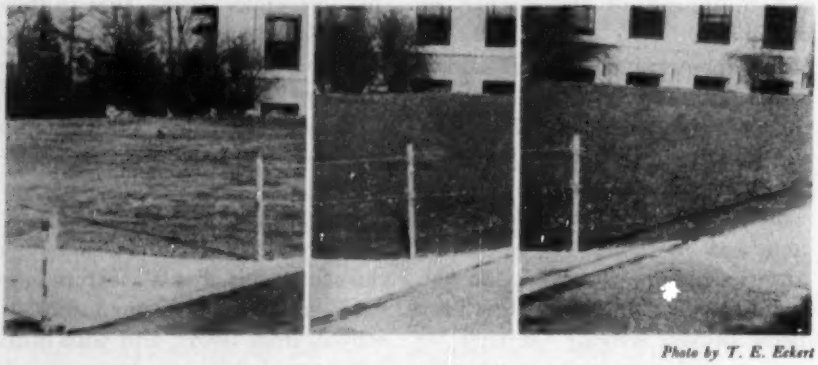


Photo by T. E. Eckert

9 A.M. *12 M* *3 P.M.*

Morning, noon, and afternoon shadows, December 18—looking north

o'clock, or at some other convenient time early in the day, mark the tip of its shadow. Use a stick driven into the ground or some other marker to which you can easily return. Measure the length of the shadow if you can. At noon, mark the shadow tip again, and measure its length. Do the same at three o'clock (or later) in the afternoon. In which direction did the morning shadow point? the noon shadow? the afternoon shadow? Which shadow was shortest? Were any two about the same length? Did the shadows change as did those in the pictures on page 4? Record what you find in a notebook. Repeat your observations on other days at the same hours. What changes do you find? Try it again and again. Do you get similar results when you observe your own shadow or that of some other object? Do shadows of you, of trees, of poles, and of other objects point in the same direction at a given time; for example, at nine in the morning? Make and use a shadow board (pages 8 and 30).

Can you tell by the direction of a shadow where the sun is in the sky? Can you tell by the length of the shadow whether the sun is high in the sky or low? Can you tell by the shadows about what time of day it is? Do you see why we sometimes say "Shadows are like clocks"? In using sundials to tell time, persons have long recognized this fact.

Sunlight spots

As you watched the shadows, probably you noticed bright patches of sunlight that moved, too. Find one on the floor or on your desk, or outdoors. With chalk or the edge of a book, or in some other way, mark exactly an edge of this sunlight spot. After ten minutes, mark the same edge again. How far has the spot moved? Continue to mark and measure its movement at intervals as long as you can see it. Write the clock time beside each mark. Use a

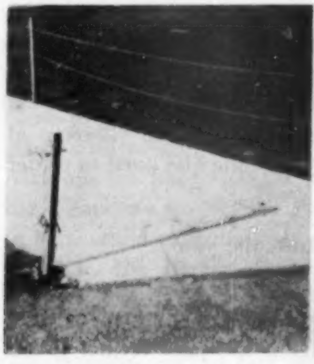


Photo by T. E. Eckert

At the left, a 12:45 P.M. shadow, December 14. A pebble shows where the tip of the same shadow was at 12:30. At the right, note the parallel shadows.

long strip of wrapping paper for your next record. Spread it in the path of your sunlight spot. You can roll it and put it away to use again later. Put it in exactly the same place each time you use it.

On the next sunny day are your marks at the same place at the same clock time? Do these sunlight spots tell you the same things that the shadows did about the position and the height of the sun in the sky? Can you learn about what time of day it is by watching sunlight spots? Must you adjust the window shades at about the same time on sunny days?

If you keep a record of sunlight spots or of shadows through several months, you will notice that sunlight-spot time and shadow time run ahead of clock time at some seasons and behind clock time at other seasons. The next sections of this Leaflet may help you understand why.

One first grade I knew marked the edge of a sunlight spot through a whole spring. The edge travelled across the blackboard at the front of the room. The children put a chalk mark on the wooden frame at the top of the blackboard each sunny day. Everyone was careful not to erase the marks.

We believe now that these daily changes in shadows and sunlight spots occur because our round earth turns, or *rotates*, on its axis, turning once, from west to east, approximately every twenty-four hours. That same turning, or *rotation*, causes night and day as each part of the earth turns into or out of the sunlight. Most persons in ancient times believed that the earth was flat and stationary. They thought that the sun moved across the sky each day, then passed below the earth, and rose ready for another trip the next morning.

To show that shadows may have helped to give people either idea, fasten a short, thick nail upright to New York State on your world globe. Use a small pat of modelling clay to hold the nail head against the surface of the globe. Then turn on a flashlight and direct its beam toward the equator of the globe. Move the flashlight slowly so its beam moves from *east to west* on the globe. The shadow of the nail will change in length and direction much as did that of the stick in the pictures. Now rotate the globe from *west to east* and hold the flashlight still. Do the shadows change, too, in much the same way?

Why we believe that our earth is round and that it rotates on its axis once in what we call *a day* are stories too long to tell here. You will find explanations in books, although some may be hard to understand.

Heat from the sun

Probably you know that heat on the earth comes directly or indirectly from the sun. Which is usually warmer – day or night? Which part of the day is usually warmest

— early morning, midday, or late afternoon? Record temperatures when you mark and measure shadows. Does the warmest part of most days come earlier or later than the shortest shadow or does it come with the shortest shadow? It is best to base your answer on several days' observations. When you get your answer, try to explain it.

Long shadows are made by slanting rays from the sun when it is low in the sky. Shorter shadows are made by the sun when it is high in the sky. Which bring more heat — slanting rays or direct rays? In a dark room, shine a flashlight straight toward a wall, and then slantingly. Keep the flashlight the same distance from the wall each time. Does this help you to understand the answer to that last question? Slanting rays spread over more surface. This little study may help you to understand why it is hotter at the equator than at the poles, and in part why summer is hotter than winter.

Lawn Laboratories and the other "laboratory" Leaflets that have come to your school have described other studies of heat from the sun. Ask your teacher to use the index in her Teacher's Leaflet for Fall 1952 to help you locate them. Look, too, in *Heat,* the Leaflet for January, 1935, if it is in your library.

Take temperatures in the morning, at noon, and in late afternoon on several cloudy days. Compare the changes during cloudy days with those on sunny days. Does the sun give heat even on cloudy days?

Work with a partner and take temperatures in shady places and in sunny places at the same time. Some sunny day when there is little wind, find the warmest and the coolest spots in your school yard. Are those spots the same on a windy, sunny day? Your answer may be yes or no. Why? *A Hint:* When you take air temperatures, keep your thermometer moving. In sunlight, shade the bulb.

Feel objects in sunlight and objects in the shade. Which are warmer? Dry things in sunlight and in shade. On a quiet, sunny day, dry one of two equal-sized pieces of the same cloth in the sun. Dry the other in the shade. Be sure they are as nearly equally wet as you can make them. Which dries more quickly?

In olden times, and sometimes now, people dried apples, sweet corn, and other foods in the sun to preserve them for later use. Last year in Florida I saw strips of turtle meat drying in the sun, to be made later into turtle soup. Clay dishes, bricks, and other things have been dried by the heat of the sun. Can you list other ways in which the heat from the sun is used on earth? Do you think plants and animals could live without it?

Shadows and sunlight spots through the year

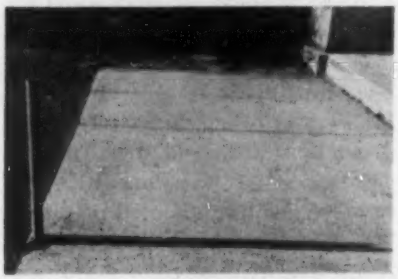
Records of shadows or sunlight spots through the year will show

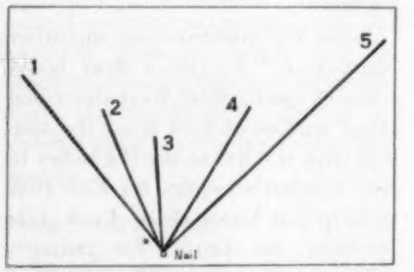
you that shadows are like calendars as well as like clocks. You can use the shadow of some outdoor object, such as a flagpole or a fence-post. A mailing-tube 20 inches long, like the one in the picture below, is a convenient object. Set it up outdoors when you are making records and keep it in your room between times. Whatever you choose, use the *same* object every time. If it is movable, like the mailing tube, it is easier to compare your records if you place it in the same spot each time.

Make a record the first sunny day of each month. Record the length and direction of the shadow at 9 o'clock in the morning, at noon, and at 3 o'clock in the afternoon. You may choose some other morning or afternoon time that is more convenient, but use the same times each month.

It may be easy to measure and record the length of these shadows, but not so easy to find a way to record changes in direction from month to month. If the shadow falls across a walk, or other hard surface, a crayon mark can be made to show direction. A heavy crayon mark lasts a while. A shadow-board, like that illustrated on this page, is a convenient way to observe and record shadow changes. Directions are on page 30.

Compare the shadows for any one of your three hours. Does the noon shadow, for example, grow shorter or longer through the spring months? in the fall months? In which month is it shortest? longest? Which shadow changes least in direction, morning? noon? or afternoon? (If you were using sun time, that shadow would not change its direction.) Can you tell from your shadows whether the sun is higher or lower in the sky at a particular time of day in summer than at the same time in winter? Is it farther to the north or farther to the south? We might ask that ques-





Shadows and Shadow Records

Left: At noon, December 17 the 20-inch mailing tube cast a 43-inch shadow, pointed to the north

Right: A shadow record **1,** *9:25 A.M., Dec. 20;* **2,** *10:30 A.M., Dec. 18;* **3,** *12:00 Dec. 18;* **4,** *2:20 P.M., Dec. 29;* **5,** *3:15, Dec. 19 (see page 30)*

tion this way: Is the sun more nearly overhead in summer or in winter? You do not need to be told the answers to these questions. You can find them for yourselves. The changes they show are important.

Thales, a wise man of ancient Greece, is said to have first recommended a 365-day year. This was about 600 B.C. He kept a daily record of a mid-day shadow. Because he lived in the northern hemisphere, he found that the shortest shadow came on a day in our early summer (now either June 21 or 22), the longest in December. By counting the days from shortest shadow to shortest shadow, or from longest to longest, he determined that a year was about 365 days long. Thales was almost right. But even a small error can make a big difference in time. Read the history of our calendar if you doubt this.

Temperature records for the same days and times of day as your monthly shadow records will show whether higher temperatures and shorter shadows go together through the year as well as through the day. Or is it the other way around? Remember, shorter shadows mean that the sun is higher in the sky. That means more direct rays. More direct rays mean more warmth.

A man I know writes often about the seasonal change of the place where the sun rises. On about March 21, it rises directly in the east and shines straight down an east-and-west road he can see. In summer it seems to rise to the north of that road. Then about September 21, it rises again directly in the east. In winter its rising place is to the south.

Sketch the eastern horizon near your home. Draw roads, trees, buildings, hills, and so on. Then show on your sketch where the sun seems to rise at different times of year. Draw your western horizon. Does the sun seem to set at different points, too?

You know that the sun rises earlier and sets later in summer than in winter. The graph on page 10 shows how the number of daylight hours differs through the year. You could make a graph like it by watching the sun. This one was made from a table of sunrise and sunset times in an almanac. Some calendars give similar information.

Heat through the year

You can see, now, two good reasons why we have warmer weather in summer than in winter. (1) Summer days are longer than winter days; more sunlight means more heat. (2) In summer the sun is higher in the sky than in winter. That means more direct rays and more heat.

Astronomers believe that the changes in shadows and sunlight spots through the year are caused by another motion of the earth. The earth, besides rotating on its axis, *revolves* around the sun once

in what we call a *year*. It moves in a not-quite circular path or orbit. It moves with its axis tilted in a slanting position, and pointed always toward the North Star. The diagram on page 11 and explanations in books may help you to understand how these facts cause our seasons. Read, too, about seasons in other parts of the world.

Light on the earth

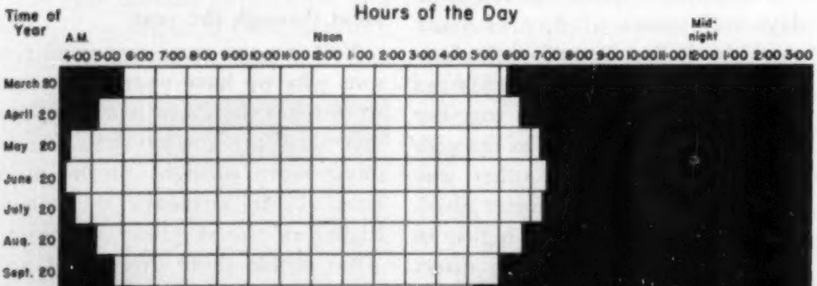
Light from the sun is important to mankind and to other living things on earth. The sun comes up, then most of us begin our day's work. Plants need sunlight to grow. Can you think of other ways light from the sun affects the earth and its inhabitants?

Your studies of shadows and sunlight spots were studies of sunlight on the earth. There are many others.

A little girl named Diane wrote, "I see the beautiful stars and the moon on the trees. The yellow on the black is very pretty." She had noticed, I believe, that the trees look black at night. Did you ever stop to think how much we depend on light to see colors? Take two boxes of the same size. The flat kind that frozen foods come in will do. Cut a big "window" in the top of one box. Cut a small "window" in the top of the other. From a piece of bright red cloth, cut two pieces large enough to cover the bottom of the boxes. Put one piece in the bottom of each box. Close the boxes. Look through your "windows." Do the two pieces of cloth look the same?

Let sunlight shine through a prism if you can get one. What

Approximate time of sunrise and sunset – New York State



In this record of daylight and dark hours through the year, each square represents one hour. White squares are daylight hours. Black squares mean darkness.

colors do you see? Sunlight shining through an aquarium sometimes breaks up into the same colors. Often you can see these same colors by looking through the edge of a pane of glass when sunlight passes slantingly through it. Rainbows are caused by sunlight shining through raindrops that act like prisms. Look in books to learn how sunrise and sunset colors are produced.

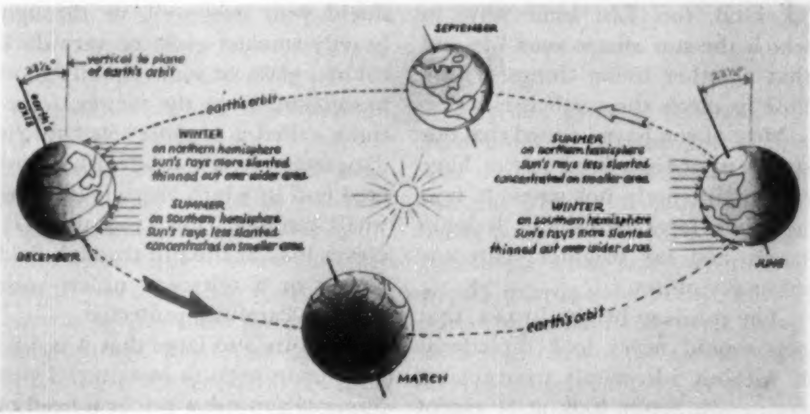
Time on the earth

Practice in your own sky laboratory until you can tell about what time it is by the sun during the day and by the stars at night. This ability might be most useful to you someday. Use shadows or just judge by the height of the sun. In former days, before clocks were common, a "sun-mark" to indicate noon was often used. This "sun-mark" was a shadow cast by the sun when it reached its highest point in the sky. Scout manuals and many books on stars give directions on how to tell time by the stars. The Big Dipper usually is used.

You could not, though, depend on sun time or star time to help you meet a bus schedule or get home just in time for a favorite radio or television program. That is because clock time is neither sun time nor star time, although it is based on both.

You can read about clock time in many books. To understand it, you must know about the sidereal day, the solar day, and the mean solar day. Read, too, how the 24 time zones in the world were set up. The Cornell Rural School Leaflet Office, Cornell University, Ithaca, New York, will gladly send you mimeographed information on this subject. It tells about sundials, too.

Sundials, you know, tell sun time. Noon on a sundial is the time when the sun reaches its highest point in the sky for that day. Astronomers



From The Stars by H. A. Rey. Courtesy Houghton Mifflin Company

The tilt of the earth's axis causes the seasons

say it reaches the *meridian.* North of the Tropic of Cancer, shadows then always point to the north. Noon by your clock, if it is correct, and noon by a sundial only rarely agree. Of course sundials are useful only in daylight hours and when there is sunlight enough to cast a shadow. If some of you older readers wish to make a sundial for school or camp, refer to some of the books listed on pages 31 and 32 or to other books for directions. Read also about other ways to tell time and about hour-glasses, water-clocks, and other instruments.

The size of the earth

It is said that Eratosthenes, a Greek, was the first to try to measure the size of the earth. He made his measurements in Egypt about 275 B.C. Some of the older Leaflet readers may like to read how he did it, but you will need some knowledge of geometry to understand his method.

Eratosthenes' measurement was not quite correct, but he showed *how* to find the distance around the earth. That was important because measurements of sizes and distances of other heavenly bodies depend on our knowledge of the dimensions of the earth.

The earth and life upon it

To us and to other living things on it, our earth is surely a most important heavenly body. We should use our eyes, our intelligence, and our imagination to learn all we can about it, and to make it the best possible place in which to live.

The Sun

THE sun is important to mankind, too. List some ways in which the sun affects your life and that of other living things. Think how it affects the earth itself.

Most of you have learned that our sun is a medium-sized star, a huge ball of intensely hot gases. It may not look large to us, but it looks larger and far brighter than any other sky object.

The sun is so bright, in fact, that you should never look directly at it without adequately protecting your eyes. Never look at it except through one or more dark photographic negatives large enough to shield your eyes well, or through heavily smoked glass, or very dark colored glass, or some equally good protection. Even the viewer, sometimes called a *pinhole telescope,* is dangerous. It is a tube with a covered end in which there is just one small pinhole. Don't risk using it. Never look at the sun through field glasses or a telescope unless your eyes are carefully protected.

The sun is so large that it is difficult for us even to imagine its size. Suppose you use a pea or a bead or a ball of modelling clay one-fourth

inch in diameter to represent the earth. How big a ball would you need to represent the sun? Divide 865,000 (roughly the number of miles in the sun's diameter) by 8000 (roughly the earth's diameter in miles). Multiply one-fourth inch by your answer. Would a ball the diameter of a bushel basket be large enough? Have you ever seen a beach ball or a balloon that would do? Check your answers on page 19.

While you are doing arithmetic you might figure how far apart to put your quarter-inch earth and your how-many-inch sun. Use the same scale: $\frac{1}{4}$ inch = 8000 miles. Books tell you that the average distance from the earth to the sun is about 93,000,000 miles. $93{,}000{,}000 \div 8000 = ?$ Your answer $\times \frac{1}{4}$ inch $= ?$ Is there room in your school room to place your "earth" and "sun" the proper distance apart? Or would you need to move out into your school yard? or even farther? Check your answers on page 19.

When you have made and placed your "earth" and "sun" as suggested, look at pictures in books. See whether they picture the heavenly bodies on the same size scale. Often only a small part of the sun is shown, or pictures of the sun are much too small to be in correct proportion. Some books point out these facts. Now do you know why the sizes of heavenly bodies and the distances between them are not usually pictured according to the same scale?

Can you imagine our huge sun, sending light and heat off in all directions? The earth receives only a small part of all the sun's heat and light, but we are dependent on the sun not only for our comfort but for our very life.

Surely you will want to turn to books to learn much about the sun that has not even been mentioned in this Leaflet.

The Moon

Who has not looked at the moon, that familiar sky object, the nearest to our earth in all the heavens? You have seen it as a slender crescent, and as a bright, round, full moon. For a night or two in each month you do not see it at all. The ancient sky watchers saw much the same things. Centuries ago they decided that the moon did not shine by its own light. Otherwise it would not change its apparent shape.

The sun gives it its light, you have probably learned. Perhaps you can understand this better if you ask one of your friends to take a fairly large mirror to a nearby sunlit hillside. Have him turn the face of the mirror toward the sun and you. You stand facing your friend, with your back to the sun. Does the mirror shine as if it were a light? If not, perhaps it will if your friend turns it a little so it reflects the sun-

light to you.

Or, take a ball, preferably a white one, and a flashlight into a thoroughly dark room or closet. Hold the ball at arm's length. Can you see it? Hold your flashlight as far from the ball as you can. Shine it on the ball. Now the ball, like the moon, shines from reflected light.

Except for the sun, the moon appears to be the largest object in the sky. That is because it is so much nearer to us than other heavenly bodies. You know how much larger an airplane looks when you stand beside it than when you see it high in the air and far away.

Add a moon model to the models of sun and earth described on pages 12 and 13. On the same scale, $\frac{1}{4}$ inch = 8000 miles, the moon would have to be represented by a bead or something about 1/16 inch in diameter, since its diameter is about one-fourth that of the earth. It is about 240,000 miles away. $240{,}000 \div 8000 = ?$ Your answer $\times \frac{1}{4}$ inch = ? It is *really* a small, near neighbor to the earth, compared with the sun, isn't it? (Check your arithmetic on page 19.)

The moon's phases

You surely have noticed that the moon seems to change in shape from day to day. We call those changes the *phases* of the moon. Remember, the moon is round; it only seems to change shape. Have you ever kept a record of the moon's phases through a month or two?

Soon after new moon is a good time to start. Many calendars tell the date for each month. We cannot see the new moon; but a few days later the moon is a slender crescent. You see it low in the western sky a little after sunset. Keep a record for every moonlight night. Your record might look like the one on page 18. Make it at the same time each night as long as you can.

A sketch like the one on page 19 is another kind of record. First, sketch your horizon with east at the left; then south; then west. Put in hills, trees, buildings, or other objects that will help to locate the moon's position.

If you enjoy photography, use photographs of the horizon. Take one picture as you face east, another

The Moon

3¾ days old *6¼ days old* *9¾ days old*

as you face south, and one as you face west. Try to include some conspicuous landmark such as a building or a lone tree in each. Trace a silhouette of each horizon from your photographs. Use them instead of the sketch.

Draw the moon where you see it each time you make an observation. Try to make your observations at the same hour and from the same spot for several days. Put the date and the time below each sketch. Did you make each drawing the right shape? Did you place the rounded edge correctly? Check your records with those of your friends. Are all of you right?

About how many nights can you see the moon at the same early evening hour? When you can no longer see it at that time, must you look earlier or later? Between new moon and full moon, is the western edge of the lighted part of the moon always rounded? always the same shape? Is that true of the edge toward the east? Between full moon and the next new moon, are the same things true?

The moon between new moon and full moon is called a *waxing moon;* between full moon and the next new moon, a *waning moon.* Is this old rhyme about the moon true?

> Points to the east,
> Shine, be increased.
> Points to the west,
> Wane, be at rest.

The moon's light

The full moon gives much more light than any other object in the night sky. Is moonlight bright enough to cast shadows? Is it ever bright enough to read by?

Earthshine on the moon

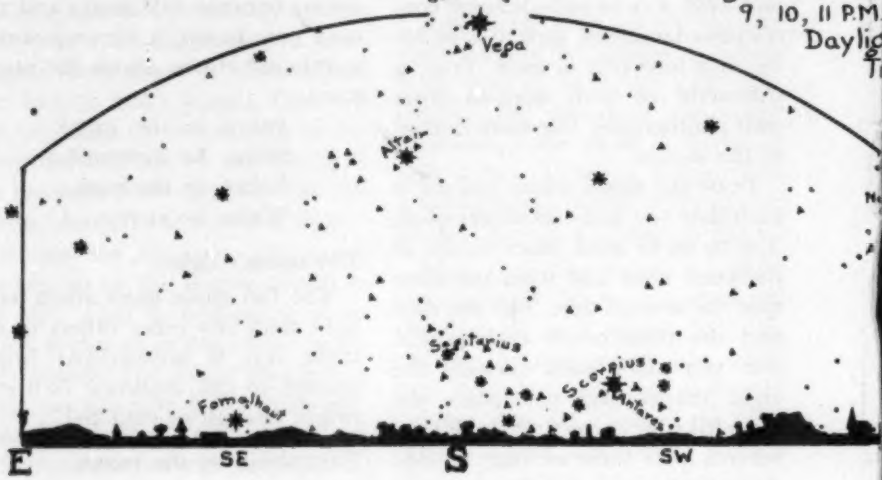
When you observed the bright crescent moon shortly after new moon, did you see the rest of the round moon marked out dimly? This "old moon in the new moon's arms" is the result of "earthshine." It is sunlight reflected from our earth to the moon, and back again. Read about it.

Look in books, too, for diagrams and explanations of why we see the phases of the moon. The answer will be *revolution of the moon around the earth.* The moon's revo-

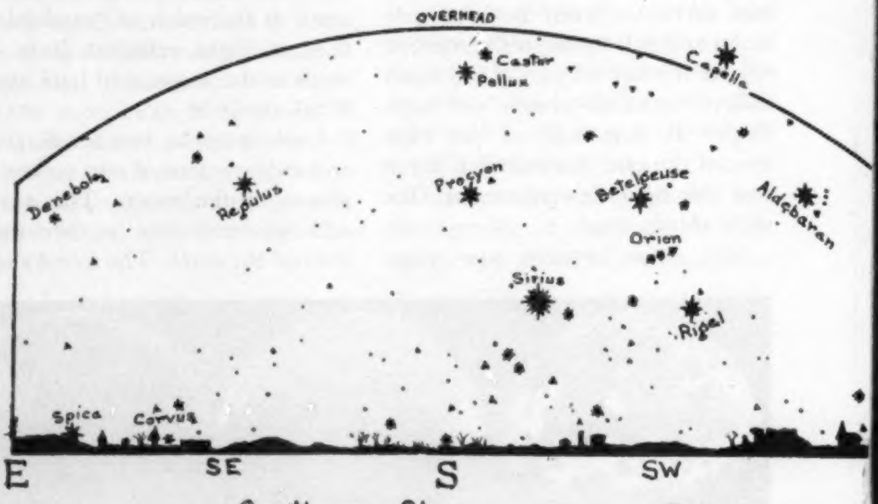
The Moon

20 days old *24 days old* *27 days old*

August and S
9, 10, 11 P.M.
Daylig ht
T m



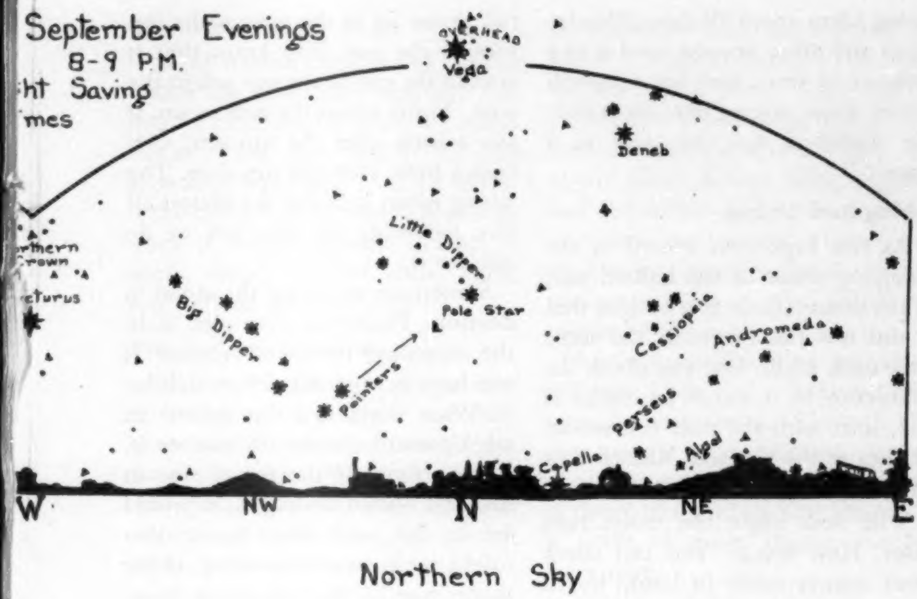
Southern Sky

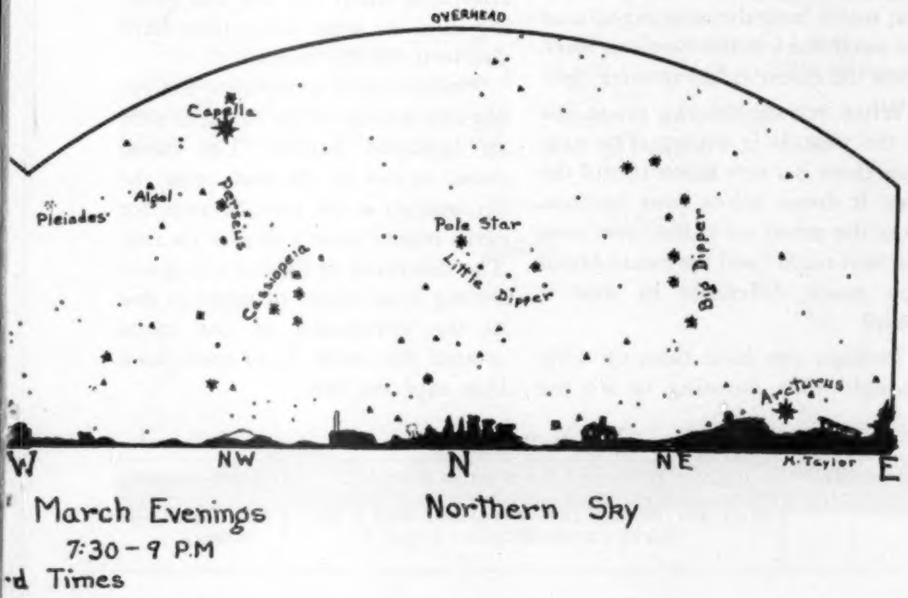


Southern Sky

February and N
9:30 - 11 P.M.
Standar d

From "Star Project," by Madale B. S





e B. Sawyer and Grace M. Seymour

lution takes about 29 days. The Indians and other peoples used it as a measure of time. Our word month comes from *moon,* but our calendar month is not the same as a "moon."

Rising and setting

As you kept your record of the changing shape of the lighted part of the moon, surely you noticed that it did not rise or set at the same time each night. Did you check the difference by a watch or clock? If not, start with the next full moon. It rises as the sun sets. Record that time.

The next night the moon rises later. How much? You can check your answer easily in books but it is more fun to check it first with other observations of your own and of your friends. Does it rise about that much later the next night? and the next? See whether you can learn when the moon at last quarter rises.

When you see the new moon low in the west, it is setting. The next time there is a new moon record the time it drops below your horizon. Does the moon set at the same time the next night? and the next? About how much difference in time is there?

Perhaps you have been up early enough some morning to see the *full moon* set in the west as the sun rose in the east. You know that it rises in the east as the sun sets in the west. Think about the *new moon.* It sets a little after the sun sets, so it rises a little after the sun does. The young moon is in the sky almost all day, following the sun, but we do not see it.

Sometimes we do see the moon in daytime. Have you ever seen it in the morning? in the afternoon? If you have never noticed it, watch for it. What shape is a day moon? In what part of the sky do you see it, east or west? If the moon rose in the east about midnight, it would set in the west about noon. You might see it in the morning. If the moon rose in the east about noon, it would set in the west about midnight. You might see it late in the afternoon when the sun was growing dim. At what other time have you seen the day moon?

Probably you know that the rising and setting of the moon is only an *apparent* motion. The moon *seems* to rise in the east, cross the sky, and set in the west, because our earth rotates once a day on its axis. The difference in time of rising and setting from night to night is due to the revolution of the moon around the earth. Read some book that explains this.

The Moon's Phases

Date	Hour	Position of the moon in sky	Moon's shape
		(*East, west, southeast, south, or southwest. High or low.*)	(*Drawing or paper cutting.*)

The colors of the moon

A boy named Lloyd asked, "What makes the moon turn different colors?" I have seen it when it looked white. That was when the sky around it was light. It looks yellow if the sky is dark. It may look orange when it shines through air that is dusty, smoky, or not clear. Have you noticed other colors?

The surface of the moon

With your own two eyes you can see that there are bright and dull areas on the moon's surface. If you can, look at the moon through a field glass. You will need help to understand what you see, so read about the moon's surface.

The moon and the earth

The moon is important to mankind because it is our nearest sky neighbor.

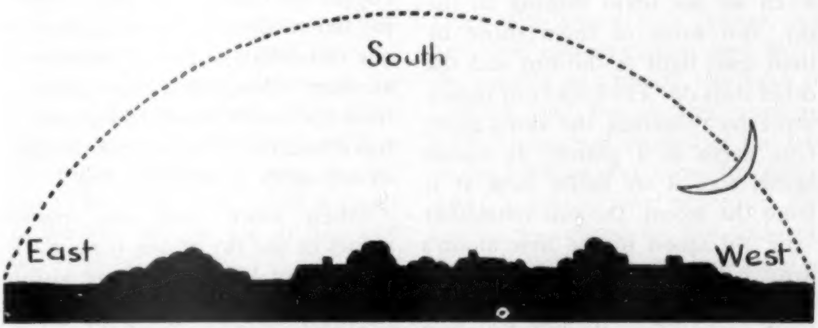
It is partly responsible for tides.

When it passes directly between the earth and the sun it causes an eclipse of the sun. When our earth is directly between the sun and the moon, the moon is eclipsed. Eclipses do not occur often. They can be predicted. Newspapers, radio, and many books on astronomy tell about them before they happen, and tell where and when they will be visible. See one if you can. Then read an explanation. Be sure to protect your eyes if you watch an eclipse of the sun.

Ancient peoples were afraid of eclipses. They did not know they were natural events. Through the ages people have believed strange superstitions about the moon. Most of them, like the tale that the moon is made of green cheese, are far from true.

Check your arithmetic here

$865{,}000 \div 8000 = 108$ (nearly)
$108 \times \frac{1}{4}$ inch $= 27$ inches (diameter of your model sun)
$93{,}000{,}000 \div 8000 = 11{,}625$
$11{,}625 \times \frac{1}{4}$ inch $= 2906$ inches, or 242 feet
$240{,}000 \div 8000 = 30$
$30 \times \frac{1}{4}$ inch $= 7\frac{1}{2}$ inches



A way to record the moon's phases

Planets

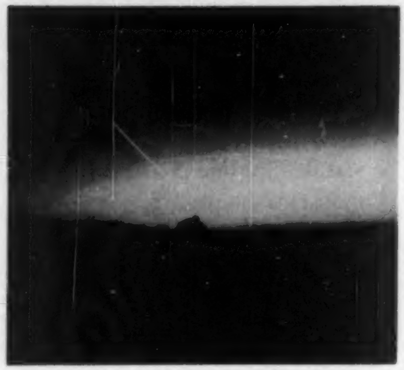


Photo by Martha Carpenter

Trails of Venus (left), Castor, and Pollux, setting. Scituate, Massachusetts, June 13, 1938, 8:24 P.M. to 9:28 P.M., eastern standard time

IN school one day last fall a fourth-grade child wrote, "Last night I saw a star that was out at five o'clock." That "star" was not a real star. It was the planet Venus. I saw it, too. It shone clear and bright while the sky was still too light for the real stars to show.

Planets look like very bright stars when we see them shining in the sky. But none of them shine by their own light as the sun and the other stars do. They, like our moon, shine by reflecting the sun's light. Our earth is a planet. It would shine, too, if we could look at it from the moon. Do you remember "the old moon in the new moon's arms"?

Eight planets besides our earth are known. They all revolve around the sun. They are much nearer to the earth than is any star except our sun. That helps to make those we see look so bright.

Four of the nine planets can be easily seen from the earth with unaided eyes. They are *Venus, Mars, Jupiter,* and *Saturn.* A fifth, *Mercury,* can be seen sometimes but is usually difficult to spy. We see these planets at different times of year and at different hours – just after sunset, through all or only part of the night, or only just before sunrise. Often we call a planet that is in the west just after sunset an "evening star," and one in the east just before sunrise a "morning star." Different planets are morning stars or evening stars at different times and there can be more than one morning star or evening star at a time. Ancient sky watchers noticed these bright planets. They observed, too, that these objects were not part of any sky pattern or constellation, like Orion or the Big Dipper or Cassiopeia, (Kăs′-ĭ-ō-pē′-ya) but seemed to be sometimes in one constellation and sometimes in another. They called them *planets,* from the Greek word, to wander. It was centuries before people thought of our earth as a planet, too.

Often more than one planet shines in the sky at one time. Early in January 1953 three were visible just after dark. Brilliant Venus and red Mars were low in the southwest. Bright Jupiter was almost

overhead. All three will be in the evening sky through March. Then Venus will become a morning star. Do you know how to find what planets will be visible when you receive this Leaflet? Look in almanacs, or in some of the magazines mentioned on pages 31 and 32. Many books on sky study give this information, too, but you may need help to understand their way of telling. Newspapers sometimes tell; so does one radio program I hear.

When you know what planets to look for and where to look, you are ready for some sky-laboratory planet studies. It might help if you and your teacher went outdoors during the day and pointed to the part of the sky where you might expect to see the planet or planets at night. Perhaps the science teacher or someone else who knows about such things would help.

Notice colors. Venus, usually the brightest planet, seems to shine with a brilliant white light; Mars with a reddish glow. Jupiter, usually the second in brightness, has a yellow-white light. Saturn is faintly yellowish and gives a dull, steady light.

Notice how many hours of the night different planets are visible. Venus, for example, is seen only in the early evening or close to sunrise. That is because Venus is closer to the sun than we are. It rises and sets close to the sun. For the same reason we do not see Venus high in the night sky. Jupiter, however, may sometimes be seen all through the night, sometimes high, sometimes low, and in the east, or south, or west. Is Jupiter farther from the sun than we are?

Notice whether certain planets seem to vary in brightness at different times. Try to find the explanation.

If you are patient and careful enough to study the courses of different visible planets, you may discover that all of them travel on about the same broad path. The sun and the moon travel along that path, too. Use your horizon sketches or photographs (page 14) and draw in the position of any visible planet at the same hour on clear evenings. Jupiter would be a good planet to start with.

The line called the *ecliptic* on sky maps is the apparent path of the sun. The moon and the planets all seem to travel across the sky, never far from this ecliptic. Read about the ecliptic and the signs of the zodiac.

Orion and its "trail"

The photograph on page 27 was taken with a press type camera, but any good camera can be used. With the camera on a tripod, the focus at infinity, and the shutter opening *f* 4.5, Orion was located at the left of the field, to give room for trails. After a one-minute exposure, the shutter was closed for five minutes, then reopened for an hour and a half. The print was on No. 4 high contrast paper.

Sirius made the bright trail at the lower left.

The Stars

"The sky at night is beautiful. It looks like a picture," Stephen wrote at school. How many of us have had that same thought as we looked up at a clear, starry sky when it seemed that millions of stars were out!

Astronomers tell us that at any one time and place the number of stars a person can see with his two eyes alone is from 2000 to 2500; certainly not more than 3000. More can be seen with the aid of a field glass. Millions are visible through a great telescope. Most of us, on most nights, would have 2000 stars or less to count if we were to undertake such a task.

You realize, don't you, that you can study stars winter or summer, spring or fall, night or day? Whatever the time or season, you have only to go out and look at the sky. Go as often as you can, at different hours and in different seasons.

For night star-gazing, clear, moonless nights are best, but you can see many stars even with some moonlight or clouds. When you are accustomed to watching stars on clear nights, it is fun to try a partly cloudy evening. Things look quite different.

A place where no bright lights, tall buildings, or trees obstruct your view is best. Take with you a friend or two, and a chart or map of the sky for the proper date and time of day. A flashlight will help, both to see the chart and to point out stars in the sky.

A good time to begin is shortly after sunset. Then you can easily locate the planets in the sky at that time; and you can watch one bright star after another wink into sight all over the sky. Perhaps you will realize as you watch that more stars than our sun have been in the sky all day. You could not see them because the light from our nearby star, the sun, made the sky so bright that the stars did not show. You can see how this happens if you turn on a light near a window in a sunlit room. I wonder whether a girl named Betty can guess now "why the stars don't come out by the moon," when the moon is bright.

By now, do you know what I meant by day-time star study? The sun, of course! There is, though, another kind of day star-study you can do. You can get ready for night-time star-gazing by studying star books, maps, or charts and deciding what to look for and how to locate what you wish to see. You can even make your own star maps. You might start with the Big Dipper and the North Star (see the illustration on page 24). Then add Cassiopeia (kăs′-ĭ-ō-pē′-ya) as shown on page 25. Add others as you are ready for them.

In the daytime, too, you can find answers to questions that are sure to come up. At school you will have

your teacher and books to help you, and you can find and do things to help you understand what you read and see. Perhaps you can invite someone who knows about astronomy to visit your school. Your teacher or your sky expert might even go star-gazing with you at night. Possibly someone in your community owns a telescope and would be willing to show it to you and let you use it.

Bright stars and dim stars

When you have watched the sky just after sunset, you will know that all of the stars do not come out at once. As the sky darkens, more and more appear. Are the later ones usually as bright as the first stars you see?

If you are up before daylight while the stars are still out, notice that they disappear gradually as dawn approaches. Which can you see longest, the bright ones or the faint ones? Remember that you may see a planet or two, also.

Which stars do you see when the sky is somewhat cloudy, the bright ones or the dim ones?

Like our sun, the other stars are huge balls of bright glowing gases. They shine by their own light and give off heat, as our sun does. How bright a star appears to us depends on: (1) how much light it gives off, and (2) how far away from the earth it is.

Astronomers have a word for the apparent brightness of a star to us on earth. It is *magnitude*. Some of you may wish to read about star magnitudes, and to find examples in the sky of the different magnitudes that are visible to the naked eye.

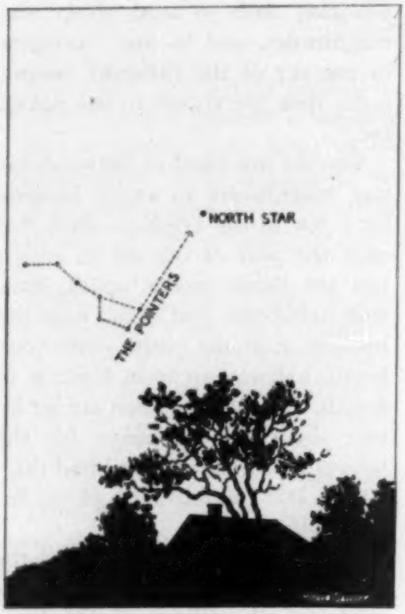
You do not need to know about star magnitudes to enjoy looking for a few of the brightest stars. Record the part of the sky in which you see them: north, south, east, west, northeast, and so on; near the horizon, near the zenith (over your head), halfway up from horizon to zenith, and so on. Then try to locate them on star maps for the proper date and time, and find their names. Did you mistake a planet for one of them?

The pale glowing band across the sky that we call the *Milky Way* is made up of millions of dim stars. Look at it with a field glass if you can. It is difficult to see except when the night is dark and clear.

The sizes of stars

Sharon asked, "Why do the stars look so little?" Another fourth-grade child wanted to know, "Is it true that sometimes a star is bigger than the earth?"

As you look at the stars, none *appear* large. All are just tiny glowing points in the sky, because they are too far away to look any other way. You know how an airplane flying away from you seems to become smaller and smaller until it is just a speck – and then it is gone. No star that we can see is smaller than the earth. Many are larger than the sun. Astronomers have



How to find the North Star

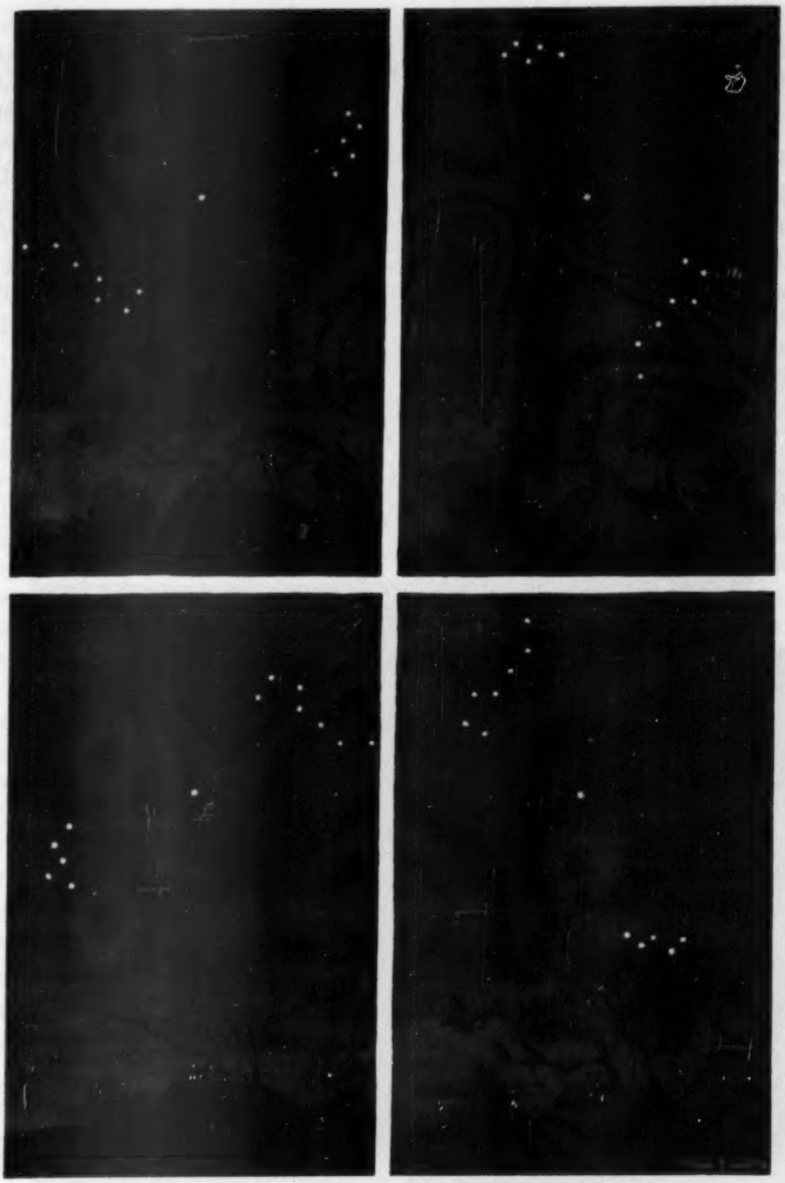
learned much about the stars that our eyes alone cannot see. Read about these things in some of the books mentioned on pages 31 and 32, and in other places, too.

Star patterns

As you observe stars, you notice that some seem to form patterns in the sky. These patterns, which we call *constellations,* remain the same, as the stars appear at night, cross the sky, and disappear at dawn. They look the same, night after night, year after year. Probably they looked almost the same to sky watchers centuries ago. Perhaps the easiest way to become acquainted with the sky at night is to learn to recognize a few constellations and then to watch them through the seasons in their nightly march across the sky.

The **Big Dipper** is easy to pick out, and is a good landmark from which to learn other constellations. If you do not already know it, look at the illustration on this page; or find a diagram in some book; or get someone to show it to you. Then, early some evening, go outdoors, face north, and locate the Big Dipper, then the Pointers, and then the North Star. The pictures on page 25 will help. The North Star is about five times as far from the Pointers as they are from each other. Note carefully the position of the Big Dipper. A horizon sketch such as you used for your moon record will help. Mark the spot where you stood. Return to the same spot an hour later. The Pointers still point to the North Star, but the Dipper has moved. In what direction? Record the change. Return an hour later. The Dipper has moved still more. Does it move as if it were circling a huge clock face with the North Star at its center? Does it move in the direction a clock's hands go? Or, does the star clock seem to move backwards?

If you could watch the Big Dipper all day and all night you would see that, for us in New York State, it never sets. Each day it makes a complete circle around the North Star, like a clock's hands going backwards. If you imagine a line through the Pointers to the North Star as a clock hand, you can tell



Positions of the Big Dipper and Cassiopeia at 8 P.M.

October *January*
April *July*

about what time it is by the Big Dipper. Look at diagrams in star books to see how the position of the Big Dipper changes in 24 hours.

The position of the Big Dipper at any hour of the night changes from season to season (page 25). The reason for this change is the difference between star time and sun time. To tell time through the year by the Big Dipper, you would need to consider this seasonal change in position. Many books tell how to do this.

Read about the Big Dipper. It is part of a constellation called *Ursa Major,* the *Great Bear.* There is much to learn about it. Are there places where it does seem to rise and set, and others where it is not seen at all?

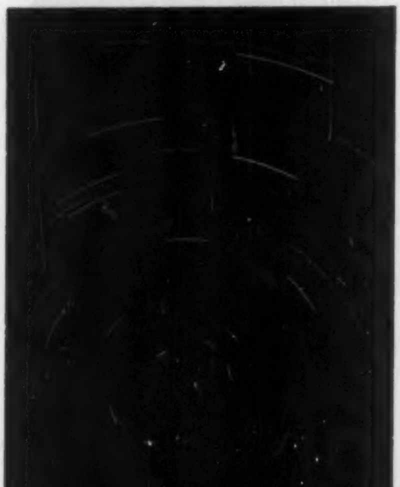


Photo by V. E. Schmidt

"Trails" of the North Star and neighboring stars. The straight trail at the lower left was made by a meteor.

The **North Star,** or Pole Star *(Polaris* is its name), is an important star. It may be seen from any part of New York State, and from most of the northern hemisphere, at any time of night, on any clear night, in any season. It never rises nor sets. At any one latitude it remains in almost the same position in the sky, day and night, summer and winter. You can see for yourself that this is true at night. Find a place near your home where the North Star appears exactly in a line with a chimney, a roof edge, or some other stationary object. Mark that place so you can return to it at intervals. Does the North Star appear always in the same position?

Do you wonder that for centuries men have used it to guide them in their travels or to help them know location and direction?

Polaris is almost exactly at the pole of the sky, the point toward which our earth's axis always points. That fact makes the whole sky-full of stars appear to turn around Polaris. That, you know, is because the earth rotates on its axis. The stars, except Polaris, only *seem* to move. We say they show *apparent motions.* Stars do have some real motions, but we cannot see them, only read about them.

Did you learn, from reading, that Polaris has not always been the Pole Star?

From the latitude of New York State, Polaris is about half-way between the horizon and overhead. Would it be in the same position in

Florida? At the North Pole?

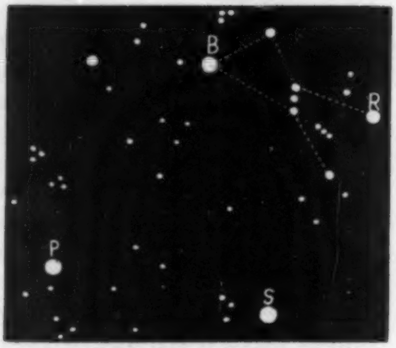
The Big Dipper, Cassiopeia (page 25), and four fainter constellations are always above the northern horizon, at the latitude of New York State. They are called the *polar* or *circumpolar constellations* because they are arranged around the pole of the sky and not far from the Pole Star. You probably will want to become acquainted with them.

From November through April of each year one can see beautiful **Orion** in the southern sky. Through December, January, and February, the constellation is high in the heavens in early evening. I have watched its brightest stars appear in the January sky before six o'clock at night and before many other stars could be seen. With the picture on page 28 to help, you should be able to find it easily. Of course, you can use star maps, too. Look for it early in the evening (it sets early in the evening in April) and again an hour or two later. Use your horizon sketch to show how much Orion has moved.

You are seeing those *apparent motions* again. If you observed one of the bright stars of Orion, or any star, carefully, you would learn that it rises each night about four minutes earlier than it did the night before. This is because a day by star time is four minutes shorter than a day by clock time (or sun-time).

Orion and its "trail"

How Richard B. Fischer took the photograph from which this illustration was made is told on page 21. The engraver enlarged into dots the first short trails of the principal stars.



Orion (top, right)
P, Procyon *B, Betelgeuse*
S, Sirius *R, Rigel*

Test this statement by choosing a star that sets behind a prominent land mark, such as a building or a hill, at a convenient hour for you to observe it. Have ready two stakes. One should be tall. Drive one into the ground where you are standing. Place the tall one so you can sight over it to your landmark. Record the exact time your star sets. Leave your stakes in place. The next night repeat your observations. Be sure to stand at the exact place. If you were careful, the time should be about four minutes earlier by your watch or clock.

Four minutes a day would be two hours a month, and 24 hours in a year. Now do you see why Orion cannot be seen in early evening from May through October? During those months, because of its times of rising and setting, it would be in our day sky, or in the night sky at times you would not ordinarily be star-gazing. Do you see why the Big Dipper appears in different positions at the same hour at different times of the year? Do you see why the same star charts can be used year after year? When you know Orion well, you can tell time by it, too.

Orion and its neighboring constellations have some very bright stars. The picture at the left will help you find two in Orion, if you need help. They are drawn larger in the picture as a way to show that they are brighter than the others. The star named *Sirius* (sĭr′-ĭ-ŭs) is one of our nearest and brightest stars. Read how important Sirius was to the ancient Egyptians.

There is something else for you to notice about those three bright stars. Betelgeuse (bĕt′-ĕl-jūz), marked B in the drawing, is reddish; Rigel (rī′-jel), marked R, is bluish white. Sirius is blue-white, too. A few other stars show these colors. Most look yellow or yellow-white. A few have an orange tint. The colors are only faint tints, but with practice you will see them more and more easily. White stars are hotter than the sun; red stars are cooler. Some books tell you more about what these differences in color mean to astronomers.

Most constellations rise in the east and set in the west as Orion does. Like Orion they are out of sight for part or all of the night during part of the year. Those times may differ from Orion's calendar. Orion is often called a winter constellation. Others are at their best at ordinary star-gazing times in

spring, or summer, or fall. You can learn many of them by yourselves, I am sure.

Star Stories

Probably you have found many stories about the stars and other sky objects. I hope you have read or will read some of these stories. Some help you to know how stars and other objects in the sky got their names. Some tell what ancient peoples believed about the heavens. Remember, though, that these are just stories. Remember, too, that there are superstitions about the stars that are not true, like wishing on a star. Learn what some of them are, and don't be fooled by them.

More Astronomy

WATCH for Northern Lights, the *Aurora Borealis.* The picture of them on this page was taken in Alaska. Watch for meteors, too, and read about both. There is much to be learned about every subject discussed in this Leaflet. You will want to understand better how astronomers have learned and are learning more and more about astronomy and to know more about the instruments they use. Read especially about the 200-inch Palomar telescope. Learn something about the astronomers, too; some of past times and some who are living now.

Photo from Wyman's Photo Service, Fairbanks, Alaska

Northern Lights in Alaska

Some Things to Do

A planisphere—size, 6 by 6 inches

1. Learn to use a planisphere. A planisphere is a star-finder that can be set for any hour or date. For a small sum you can buy the parts needed with directions for making the one illustrated on this page (page 31). Or, you can buy several types and sizes.

2. Make and use a shadow-board. The record shown on page 8 was from a shadow board made of a 5-inch by 8-inch piece of stiff corrugated cardboard A board 8 inches by 12 inches would be better. Drive a slender nail, as shown, up through the cardboard from the underside. About an inch of nail should extend above the board. Fasten the nailhead securely with a piece of tape. To make a record, fasten a white card or piece of paper securely to the board. Place the board in the sunshine with the side where the nail is toward the *south.* The board must be square with the points of the compass and level. It need not always be placed in the same spot. But, when you have located it correctly and levelled it, you may wish to fasten it in place or mark the spot so you can easily place the board correctly again. Draw the shadow of the nail in the morning, at noon, and in the afternoon. Mark the time and date. Use a new record sheet for each day.

3. Make a star-trail photograph. The polar stars are easiest. Choose a clear, moonless night, and a place free from bright lights. Point the camera at the North Star and fix it firmly in position with blocks of wood on a window sill, or on a tripod. If the camera is a focussing model, focus for great distance. If the camera has a diaphragm, open it wide. Set the shutter for time exposure. Open the shutter, being careful not to move the camera. After from one to six hours, close the shutter. Note: When you take your film to be developed, be sure to tell what the picture is. Otherwise it may be considered not worth printing.

4. Look at the moon, planets, or the Milky Way with a field glass or a small telescope. Some of you may want to make a telescope. You will find directions in books.

5. Visit an observatory or a planetarium if you can.

Some Books and Other Helps

SCIENCE books will help greatly in your study of the sky. Encyclopedias and other books will help, too. Newspapers often tell of interesting sky events that have happened or are about to happen. The Cornell Rural School Leaflets for January 1930, September 1937, and September 1940 contain useful information.

A few helpful books and magazines are described below. You will find others in your library.

Beyond the Solar System (chiefly about stars); *The Earth's Nearest Neighbor* (the moon); *The Sky Above Us* (Solar system and stars); *The Sun and its Family*. All by Bertha M. Parker. Row, Peterson and Company, Evanston, Illinois. 1941. From 34 to 36 pages each. These pamphlets, illustrated in color, contain much interesting information. *The Sky Above Us* is for grades 4 to 6, the others for junior high school.

The Constellations and Stars. By E. Laurence Palmer. Slingerland-Comstock Company, Ithaca, New York. 1948. 40 pages. An inexpensive booklet that contains star charts and the necessary parts and directions to make a planisphere (see page 30).

A Dipper Full of Stars. By Lou Williams. Follett Publishing Company, Chicago, Illinois. 1944. 170 pages. An attractive book that contains star myths, interesting information and helpful illustrations. Best for grade 7 and above.

How the Sun Helps Us. By Glenn O. Blough and Ida B. DePencier. Row, Peterson and Company, Evanston, Illinois. 1945. A 36-page booklet easy enough for third or fourth graders to read.

Introducing the Constellations. When the Stars Come Out. Both by Robert H. Baker. Viking Press, New York City. 1937, 1934. 205, 188 pages. Two well-illustrated, helpful books for older readers. Directions for telling time by the stars, and descriptions of telescopes, observatories and planetariums are included.

New Handbook of the Heavens. Edited by Hubert J. Bernhard, Dorothy A. Bennett and Hugh S. Rice. 2nd ed. New American Library of World Literature (Mentor Books), New York City. 1950. 240 pages. A useful inexpensive guide for older students.

Our Starland. By C. C. Wylie. Lyons and Carnahan, Chicago, Illinois. 1942. 378 pages. Includes information about time and the calendar, sky stories, and star maps. For grades 4, 5, and 6.

Planet Earth. By Rose Wyler. Henry Schuman, Inc. New York City. 1952. 156 pages. For ten-to-fifteen-year-olds. About the earth, the sun, the moon, time, astronomers, and other subjects.

Starcraft. By William H. Barton, Jr. and Joseph M. Joseph. McGraw-Hill Book Company, New York City. 1938. 228 pages. A guide to star study, that includes how to build a telescope and other instruments; how to make various models, star maps and sky charts, a star clock and a sundial; information about some famous astronomers.

The Stars. By H. A. Rey. Houghton Mifflin Company, Boston, Massachusetts. 1952. 143 pages. A large attractive book that contains charts for different times and seasons and a helpful section, *Some Whys and Hows* that deals with subjects such as time, the seasons, latitude, and the zodiac.

Stars. By Herbert S. Zim and Robert H. Baker. Simon and Schuster, New York City. 1951. 157 pages. A small inexpensive guide to the sky. Illustrated in color.

The Story of Our Calendar. By Ruth Brindze. The Vanguard Press, Inc., New York City. 1949. 64 pages. A beautiful book that tells how time has been measured and about our calendar. For grades 4 to 6.

Sun, Moon and Planets. By Roy K. Marshall. Henry Holt and Company, New York City. 1952. 129 pages. Good information for seriously interested readers of junior high school age or older. Many well-explained diagrams.

Sun, Moon and Stars. By William J. Skilling and Robert S. Richardson. McGraw-Hill Book Company, New York City. 1946. 274 pages. A well-illustrated book, for grade 7 or above, that includes things to do, and information about astronomers and observatories.

The World Almanac and Book of Facts, 1953 edition. Published annually by the New York World-Telegram and The Sun. A paper-covered book, on sale at newsstands, which contains much useful information of value to teachers and high school students.

Nature Magazine. The American Nature Association, Washington, D. C. Published ten times a year. In each issue is an easy-to-use star map and information about planets and interesting astronomical events. For readers of many ages.

Science News-Letter. Science Service, 1719 N. Street N.W., Washington 6, D. C. One issue of each month has clear, useful sky maps and excellent articles about astronomy. Best for high school.

Sky and Telescope. Sky Publishing Company, Harvard College Observatory, Cambridge 38, Massachusetts. An excellently illustrated monthly magazine for readers of high school age and above. It has an observer's page, an astronomy club page, and sky maps.

Published by the New York State College of Agriculture at Cornell University, Ithaca, New York. L. R. Simons, Director of Extension. Published and distributed in furtherance of the purposes provided for in the Acts of Congress of May 8 and June 30, 1914.